REMARKS

This is in response to the Office Action February 15, 2005. With this response, claims 1, 9 and 20-22 are amended, claims 2 and 20-21 are canceled, new claims 25-41 are added and all pending claims 1 and 3-19 and 22-39 are presented for reconsideration and favorable action.

In the Office Action, the Examiner rejected independent claims 1 and 24 based upon Schultheiss and Locke. However, it is believed that the presently presented claims are patentably distinct from these references.

In the claim set as amended herewith, the following amendments have been provided:

- In the independent claims, it has been further specified that the first frequency band consists of frequencies having a relatively high penetration through water and forming a relatively wide radiation beam
- In the independent claims, it has further been specified that the center frequency of the second frequency band is at least 2 times a center frequency of the first frequency band.
- A new claim 25 has been added specifying that the first frequency band consists of frequencies within a range of 10 GHz+/-5% or below, and the second frequency band consists of frequencies within a range of 25 GHz+/-5% or above. This features is also the subject of new claim 30.
- A new claim 26 has been added, specifying that the first frequency band consists of frequencies below 12.4 GHz, and the second frequency band consists of frequencies above 22 GHz. This feature is also the subject of new dependent claim 31 and new independent claim 35.

- A new claim has been added, specifying that the center frequency of the first frequency band is about 10 GHz or below, and the center frequency of the second frequency band is about 25 GHz or above. This feature is also the subject of new dependent claim32 and new independent claims 36 and 39.
- A new claim 28 has been added, specifying that the bandwidth of the first and second frequency bands are within the range 0.5-2 GHz. This feature is also the subject of new dependent claims 33, 37 and 40.
- A new claim 29 has been added, specifying that the center frequency of the first frequency band is about 6 GHz or below. This feature is also the subject of new dependent claims 34, 38 and 41.

A common problem in radar level gauging is that one and the same frequency may not work equally well in all environments, for all applications, etc. For example, a specific frequency may be un-advantageous due to the specific conditions at hand, such as the temperature and pressure, and disturbing structures inside the tank (such as agitators).

One known way to handle this problem is to use so-called frequency agility or frequency hopping. This is discussed in the background of the application. In such systems, the transmitter frequency typically jumps around within a small frequency range of a few 100 MHz, or up to 1 GHz. Multiple frequencies are also used in CW radars both as a frequency modulated CW radar (FMCW using a range of frequencies) and multiple frequency CW radar (MFCW).

The documents primarily relied upon by the Examiner, Locke and Schultheiss, are both directed to the frequency agility type of radar level gages. Thus, even if no numerical frequency values

are specifically mentioned, the skilled addressee would expect the different frequencies used in these references to be spread out within a relatively narrow frequency range, and definitely within one and the same frequency band, such as one of the conventionally used C, X or K band.

Furthermore, in case frequencies of different frequency bands are to be used, a suitable logic has to be used in the level gauge system to make a good evaluation or averaging of the measured data, and the requirements on this logic is very different to the logic used in a frequency agility case, in which standard components could be used. This in itself is a clear indication that both Locke and Schultheiss are only concerned with frequency agility within a narrow frequency range.

However, for very difficult environmental conditions, such as environments where foam layer on the liquid or a layer of dirt on the antenna is at hand, and especially when water is at hand, frequency agility type of radar level gauges have not been considered. Instead, the only known solution to this particular problem has in the past been to use two or more different radar level gauges, operable on different frequency bands. However, this solution is expensive and in many practical situations unfeasible.

The present invention provides a solution to the above-recited problem. The present invention is directed to a radar level gauge using frequency diversity, with two or more widely separated bands, as compared to the above-discussed frequency agility, with a frequency choice over a fairly narrow range, within one and the same frequency band, and allowing standard components to be used. More specifically, the frequency bands of the present invention are defined as having a second center frequencies of the second frequency band which is at least 2 times the center frequency of the first frequency band. Further, the first frequency band consists of frequencies having a

relatively high penetration through water and forming a relatively wide radiation beam, which is typically frequencies below about 12 GHz. The second frequency band consists of frequencies having a relatively low penetration through water and forming a relatively narrow radiation beam, which is typically frequencies above about 24 GHz.

By means of the present invention, and due to the very wide separation between the frequency bands used, the present invention has proven surprisingly useful for radar level gauging in difficult environments, and thereby to improve the resulting measurement accuracy and reliability. Specifically, the present invention is useful for environment conditions where foam layer on the liquid or a layer of dirt on the antenna is at hand, and especially when water is at hand. This is due to the special dielectric properties of water, and consequently e.g. wet dirt may give a disastrous limitation of the propagation already at a layer thickness of a few tenths of a mm. Further, these installation conditions are in many cases not well known beforehand, as the tank may be old or not possible to open due to high pressure or extreme temperature in the tank, poisonous content etc, and may also develop over time.

However, the very diversified frequencies used in the present invention provide an adequate measurement performance at essentially any type of environmental conditions. To illustrate the range of differences, the lobe-width for the same antenna diameter is around 4 times bigger at e.g. 6 GHz compared to 25 GHz, while the attenuation through the same layer of dirt or foam corresponds to 4 times longer measuring distance at 6 GHz as compared to 25 GHz, given the same sensitivity. With the same measure the possible range at 6 GHz is around two times the range at 10 GHz given the same layer of dirt and the same antenna size. Thus, the widely separated frequency bands of the present invention utilize the differences in attenuation due to foam on

the surface, wet dirt, etc, and the differences in beam-width, to provide correct and reliable measurements regardless of the specific conditions at hand.

Such troublesome environmental conditions situations could not be handled adequately in the prior art solutions, related to frequency agility type of radar level gauging.

In the present invention, the higher frequency band will be more affected (decreased in amplitude) by foam on the surface and dirt on the antenna, while the echo in the lower frequency band will be less clean (more background noise) as the wider antenna lobe is more likely to pick up echoes from disturbing objects. Thus, the measured echoes can be converted to a number of logic variables from which it is deduced which of the frequency bands that are likely to give the best measured level value or if a weighted average of two or more frequency bands will give the most reliable level value. Within each frequency band the same function as in the classical frequency agility process can be performed but much more important is the possibility created by the present invention to avoid signals with very low amplitude if a high frequency radar level gauge should be used under foamy conditions or to avoid disturbances from tank structures when non foamy liquids with low reflectivity are measured.

To conclude, the present invention as defined in the new claim set differs from the prior art at least in the use of frequencies within different frequency bands, and by the wide separation of these frequency bands. Such a solution is neither suggested, nor indicated, from the cited prior art. On the contrary, the prior art documents relied upon are all concerned with a totally different technique, viz. so-called frequency agility. At the date of the present invention, the inventive solution would not have been obvious for the skilled addressee, facing the above-discussed problems. Thus, the present invention cannot be regarded as being anticipated by the cited prior art,

and must therefore be considered to be patentable.

In view of the above amendments and remarks, it is believed that the present application is in condition for allowance. Consideration and favorable action are respectfully requested.

The Director is authorized to charge any fee deficiency required by this paper or credit any overpayment to Deposit Account No. 23-1123.

Respectfully submitted,

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